CHAPTER 1

INTRODUCTION

1.1 ENERGY CRISIS

Energy is one of the most important building blocks in human development, and, as such, acts as a key factor in determining the economic development of all countries. In an effort to meet the demands of a developing nation, the Indian energy sector has witnessed a rapid growth. Areas like the resource exploration and exploitation, capacity additions, and energy sector reforms have been revolutionized.

The energy crisis forced the world to look for an alternative source of energy. Energy conservation and management has become the buzz word in industrial circles and 'energy' is considered as a major component in the production cost. However, this also resulted in efficient utilization of energy. The focus of country planners changed to 'More efficiency, more productivity and reduced production cost. This resulted in an immediate, long term and multi-facet solution to the problems immerging from increased energy demands against short supplies. [1]

1.2 ENERGY SCENARIO

Energy is one of the most important factors concerned with the development of any country's economy. Many developing countries are not able to fulfill their energy demands from the resources available in their own country. The most realistic scenario would require expanded use of more efficient and cleaner technologies and expanded use of electric vehicles and biofuels. Under the desired scenario, the energy consumption would be about 12,410Mtoe/yr (compared with 7,748 Mtoe/yr in 2010) [2].

No single strategy will be sufficient to reach the desired levels of energy production consumption and CO_2 emission reduction, rather a portfolio of reinforcing strategies will be required to make the transition to cleaner and more efficient energy future.

Availability and access to energy are considered as catalysts for economic growth. The envisaged growth of the economy at 9% in the Eleventh Plan cannot be achieved without a commensurate increase in the availability of energy [3]. Over half of the country's population does not have access to electricity or any other form of commercial energy. Meeting the energy access challenges and ensuring lifeline supply of clean energy to all is essential for empowering individuals. Provision of clean fuels or at least wood plantation within one km of habitation and dissemination of technology for use of clean fuels is vital for good health. This is essential if growth is to be inclusive.

Table 1.1 depicts the consumption pattern of primary energy for the last few years, focusing on the consumption and the imports to be done to fulfill the energy demand in India [4].

Table 1.1 Primary Energy Requirements for India, 2030

FUEL	**RANGE OF REQUIREMENTS**	**ASSUMED DOMESTIC PRODUCTION**	**RANGE OF IMPORTS**	**IMPORT**
COAL INCLUDING LIGNITE	632 – 1022	560	72 – 462	11 – 45
OIL	350 – 486	35	315 - 451	90 – 93
NATURAL GAS	100 – 197	100	0 – 97	0 – 49
TOTAL COMMERCIAL PRIMARY ENERGY	1351 – 1701	-	387 – 1010	29 – 59

In year 2006-07 the indigenous production of crude oil was 33.99 million tones where as consumption was 144.88 million tones forcing to import 110.89 million tones. The country is spending Rs.2199.91 billion [3] worth valuable foreign exchange towards import of crude petroleum which could otherwise be utilized for various other development works, that might ultimately prove to be more beneficial to Indian people. To improve the present energy crisis, future energy conversion in India should be sustainable which include increase share of renewable fuel, increase efficiency of fuel conversion, reduce environmental impacts, and increase knowledge.

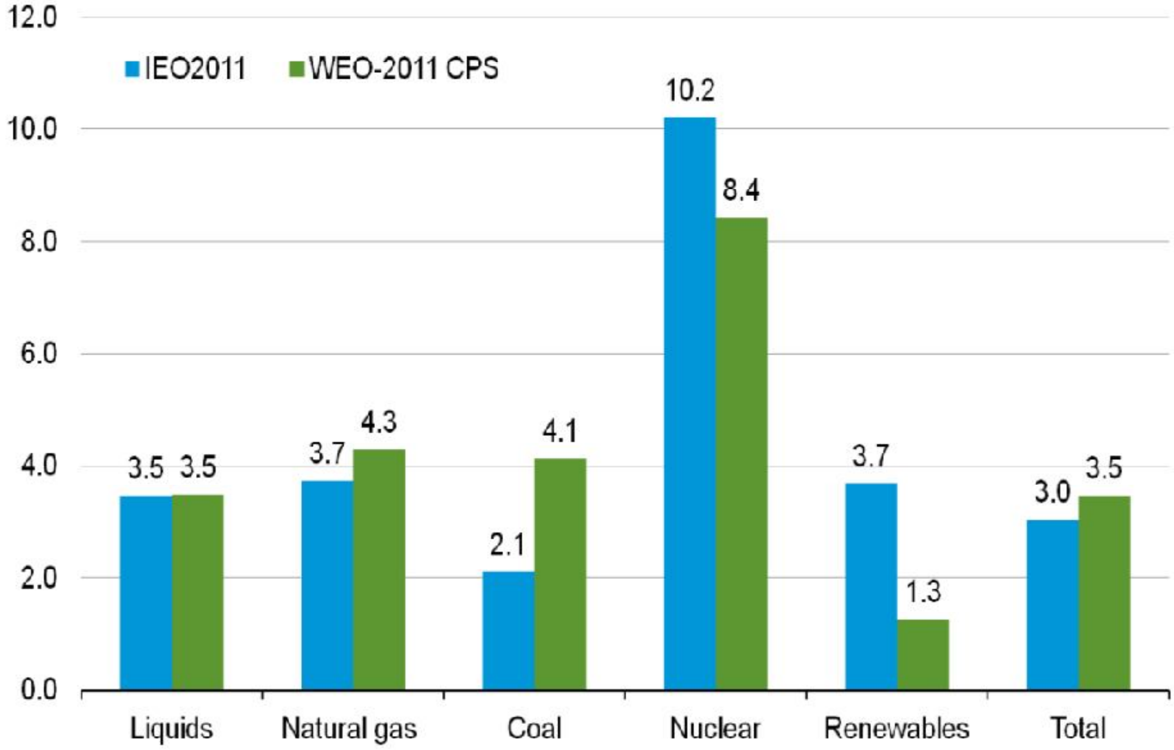

Fig 1.1: Growth in India energy consumption by fuel, 2009-2035 [5].

The Fig 1.1 compares the primary energy requirement of India in 2009 and 2010 to the world's consumption, and as already elaborated, India being a developing country, fulfills most of its primary energy demand from fossil fuels including crude oil. The oil consumption level has consistently increased despite volatility is witnessed in the prices on crude petroleum [5].

1.3 RENEWABLE ENERGY SOURCES

Due to depleting fossil fuel resources, renewable energy sources such as solar, wind, biomass, small hydro power, etc. are emerging as alternative energy options. The potential for expanding the use of RETs (Renewable Energy Technologies) for energy generation is vast in India and awaits exploitation. These renewable energy technology are environmental benign. However, the high cost of these technologies has been a limiting factor in large scale adaptation.

India's framework of policies started on time but due to unstable economic and political conditions, its implementation has been quite late. It has gained importance since formation of Ministry of Non-Conventional Energy sources (MNES) which was later renamed to Ministry of New and Renewable Energy (MNRE) in the year 2006 [6].

In India power generation by renewable energy sources was only 3,475 MW in 2002 which was 2% of the total installed capacity in the country. However, as on 10.05.2012, it has reached to 24.5 GW, which constitutes to about 12% of the total installed capacity of 199.63 GW in India[7].

1.4 FUTURE OUTLOOK

Future Energy Outlook contains projections of future energy trends and factors that could affect them, based on views of likely economic and population growth and developments in policy and technology. Together with the annual Statistical Review of World Energy, it has become a respected contribution to the global discussion on energy.

It is still expected that global energy demand is to grow by 36% between 2012 and 2030 - driven by the emerging economies. Without continuous improvements in energy efficiency, demand would have to grow much more rapidly simply to sustain economic growth.

Supply patterns are shifting. Here it demonstrates how unconventional oil and gas are playing a major role in meeting global demand. Over the period to 2030, the US becomes nearly self-sufficient in energy, while China and India become increasingly import-dependent. [8]

The global primary energy demand is projected to increase by 1.6% per year between 2004 and 2030, reaching 17.1 billion 4ones of oil equivalent (btoe) as shown in Table 1.2.

Table 1.2: World Primary Energy Demand (Btoe) [9]

	1980	2004	2010	2015	2030	2004 -2030
Coal	1 785	2 773	3 354	3 666	4 441	1.8%
Oil	3 107	3 940	4 366	4 750	5 575	1.3%
Gas	1 237	2 302	2 686	3 017	3 869	2.0%
Nuclear	186	714	775	810	861	0.7%
Hydro	148	242	280	317	408	2.0%
Biomass and waste	765	1 176	1 283	1 375	1 645	1.3%
Other renewables	33	57	99	136	296	6.6%
Total	**7 261**	**11 204**	**12 842**	**14 071**	**17 095**	**1.6%**

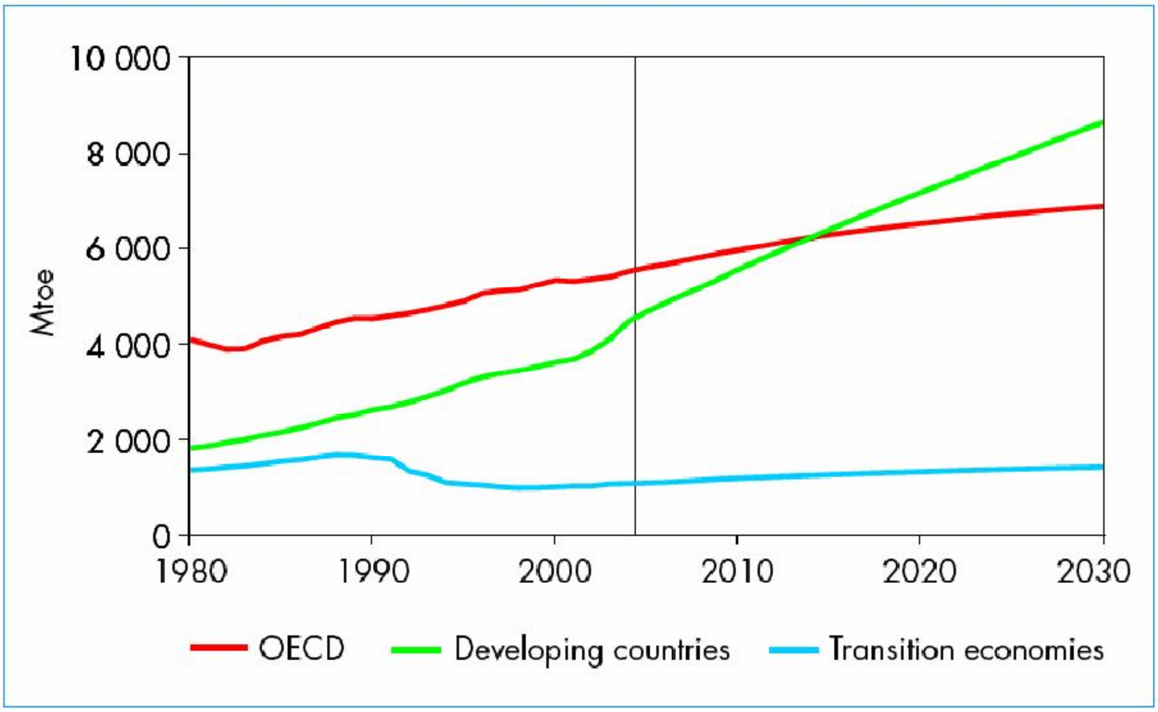

Fig 1.2: Emissions by OECD, Developing Countries & Transition Economies

The Fig. 1.2 depicts the energy consumption in developing countries and the phase where economies are in transition state, by comparing them with the Organization for Economic and Co-operation Development. The mission of the Organisation for Economic Co-operation and Development (OECD) is to promote policies that will improve the economic and social well-being of people around the world. The OECD provides a forum in which governments can work together to share experiences and seek solutions to common problems. China, India and the rest of developing Asia account for 15 mb/d, or 46%, of the 33.5mb /d increase in oil use between 2005 and 2030, in line with rapid economic growth. At 3.0% per year on average, India shall require almost double of oil in 2030 as compared to 2005[10].

The Table 1.3 lists out the various countries in the OECD and comparing the oil demand of each country since 1980 to be expected in 2030.

Table 1.3: Global Oil Demand

	1980	**2004**	**2005**	**2010**	**2015**	**2030**	**2005-2030**
OECD	**41.9**	**47.5**	**47.7**	**49.8**	**52.4**	**55.1**	**0.6%**
North America	21.0	24.8	24.9	26.3	28.2	30.8	0.9%
United States	*17.4*	*20.5*	*20.6*	*21.6*	*23.1*	*25.0*	*0.8%*
Canada	*2.1*	*2.3*	*2.3*	*2.5*	*2.6*	*2.8*	*0.8%*
Mexico	*1.4*	*2.0*	*2.1*	*2.2*	*2.4*	*3.1*	*1.6%*
Europe	14.7	14.5	14.4	14.9	15.4	15.4	0.2%
Pacific	6.2	8.2	8.3	8.6	8.8	8.9	0.3%
Transition economies	**8.9**	**4.3**	**4.3**	**4.7**	**5.0**	**5.7**	**1.1%**
Russia	n.a.	2.5	2.5	2.7	2.9	3.2	1.0%
Developing countries	**11.4**	**27.2**	**28.0**	**33.0**	**37.9**	**51.3**	**2.5%**
Developing Asia	4.4	14.2	14.6	17.7	20.6	29.7	2.9%
China	*1.9*	*6.5*	*6.6*	*8.4*	*10.0*	*15.3*	*3.4%*
India	*0.7*	*2.6*	*2.6*	*3.2*	*3.7*	*5.4*	*3.0%*
Indonesia	*0.4*	*1.3*	*1.3*	*1.4*	*1.5*	*2.3*	*2.4%*
Middle East	2.0	5.5	5.8	7.1	8.1	9.7	2.0%
Africa	1.4	2.6	2.7	3.1	3.5	4.9	2.4%
North Africa	*0.5*	*1.3*	*1.4*	*1.6*	*1.8*	*2.5*	*2.4%*
Latin America	3.5	4.8	4.9	5.1	5.6	7.0	1.5%
Brazil	*1.4*	*2.1*	*2.1*	*2.3*	*2.7*	*3.5*	*2.0%*
Int. marine bunkers	**2.2**	**3.6**	**3.6**	**3.8**	**3.9**	**4.3**	**0.6%**
World	**64.4**	**82.5**	**83.6**	**91.3**	**99.3**	**116.3**	**1.3%**

1.5 GLOBAL ENVIRONMENT DEGRADATION

In-efficient use of energy has stretched the global environment to its limits as can be seen from the unprecedented and unpleasant responses of the nature in the past few years. The indiscriminate and inefficient energy utilization has also resulted in environmental degradation which needs to be adequately studied. The process of energy generation, transport and utilization leads to air pollutants. Green house effect, global warming, acid rain, smog, deforestation, shift in climatic conditions etc. are some of the indications. Increase in the CO_2 Concentration is shown in Fig.1.3 which clearly represents that most of the CO_2 rise has taken place in post industrial revolution era. The curve of CO_2 concentration has been climbing exponentially (except in the mid 1990s when the economy of Eastern Europe and the Soviet Union collapsed). [10]

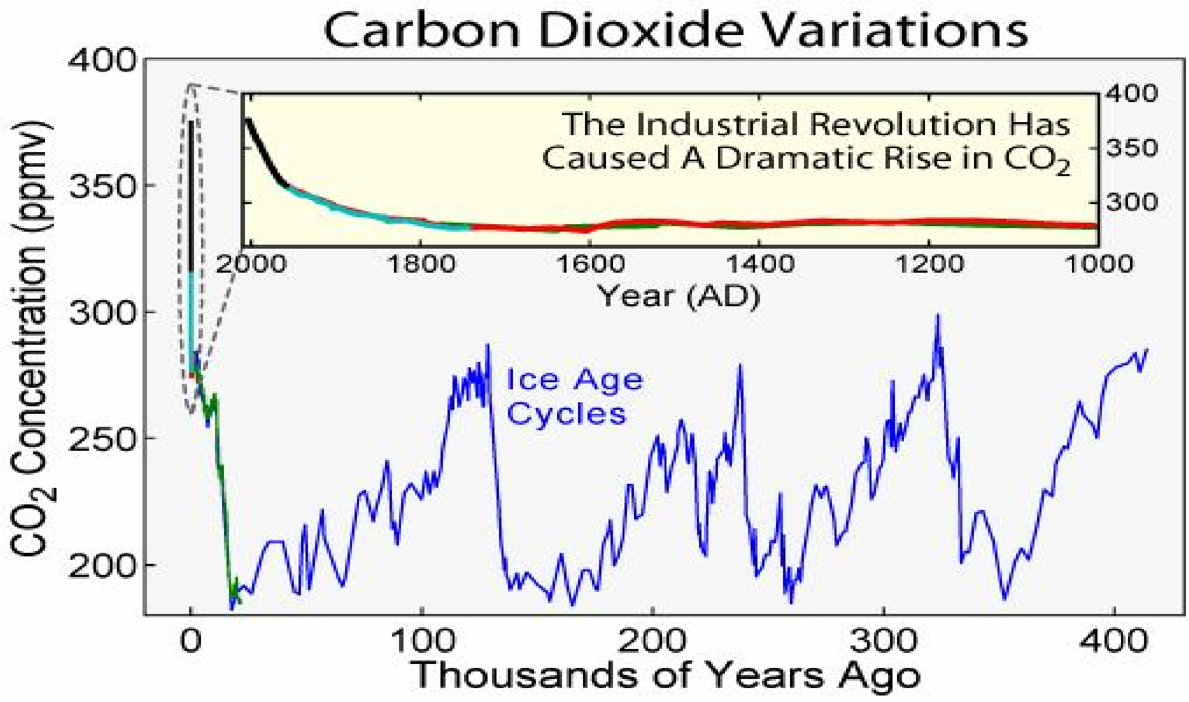

Fig. 1.3 Increase in CO_2 Concentration [5]

Scientists at the Mauna Loa observatory in Hawaii say that CO_2 levels in the atmosphere now stand at 387 parts per million (ppm), up almost 40% since the industrial revolution and the highest for at least the last 650,000 years. The figures, published by the US National Oceanic and Atmospheric Administration (NOAA) also confirm that carbon dioxide, the chief greenhouse gas, is accumulating in the atmosphere faster than expected.

The annual mean growth rate for 2007 was 2.14ppm – the fourth year in the past six to see an annual rise greater than 2ppm. From 1970 to 2000, the concentration 7 rose by about 1.5ppm each year, but since 2000 the annual rise has leapt to an average 2.1ppm.

The amount of gas added to the atmosphere is doubling every 30-35 years. Climate model projections summarized by the IPCC indicate that average global surface temperature will likely rise a further 1.1 to 6.4^{o}C during the twenty-first century

1.6 CO_2 EMISSION OUTLOOK

Global energy-related carbon-dioxide (CO_2) emissions is expected to increase by 1.7 % per year over 2004-2030. They shall reach 40.4 billion tonnes in 2030, an increase of 14.3 billion tonnes, or 55%, over the 2004 level as shown in Table 1.4. By 2010, emissions shall be 48% higher than in 1990. Power generation is projected to contribute a little less than half the increase in global emissions from 2004 to 2030. Transport contributes one-fifth, with other uses accounting for the rest. Transport remains the second-largest sector for emissions worldwide, with its share of total emissions s at around 20% throughout the projection period as has been shown in the Table 1.4. Developing countries shall account for over three-quarters of the increase in global CO2 emissions between 2004 and 2030. The share of developing countries in world emissions rises from 39% at present to 52% by 2030.

Table1.4: Increase in CO_2 by Different Sources

	1990	2004	2010	2015	2030	2004-2030
Power generation	6 955	10 587	12 818	14 209	17 680	2.0%
Industry	4 474	4 742	5 679	6 213	7 255	1.6%
Transport	3 885	5 289	5 900	6 543	8 246	1.7%
Residential and services	3 353	3 297	3 573	3 815	4 298	1.0%
Other	1 796	2 165	2 396	2 552	2 942	1.2%
Total	20 463	26 079	30 367	33 333	40 420	1.7%

Table 1.5 depicts, the increase is faster than that of their share in energy demand, because their incremental energy use is more carbon-intensive than that of the OECD and transition economies. China alone is responsible for 39% of the rise in global emissions. China's emissions more than double between 2004 and 2030, driven by strong economic growth and heavy reliance on coal in industry and power generation. China overtakes the United States as the world's biggest emitter before 2010. Other Asian countries, notably India, also contribute heavily to the increase in global emissions.

Table1.5: Contribution of Different Fuels in Global CO_2 Emissions

CO_2 emissions (Mt)					Shares (%)			Growth (%p.a.)	
1990		2004	2015	2030	2004	2015	2030	2004-2015	2004-2030
Total CO_2 emissions	588	1 103	1620	2 544	100	100	100	3.6	3.3
Coal	401	734	1078	1 741	67	67	68	3.5	3.4
Oil	164	314	450	645	29	28	25	3.3	2.8
Gas	23	54	92	157	5	6	6	5.0	4.2

1.7 CLIMATE CHANGE

Climate is referred to as the prevalent long-term weather conditions in a particular area. Climatic elements include precipitation, temperature, humidity, sunshine and wind velocity phenomena such as fog, frost, and hail storms. Thus, climate change can be defined as any change in climate over time, whether due to natural variability or human activity. The Reports by the United Nations Framework Convention on Climate Change (UNFCCC) define it as "a change of climate as attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods". Climate change is caused by increases in the atmospheric concentration of so-called greenhouse gases (GHGs). The build-up of GHGs is rapidly changing how the atmosphere absorbs and retains energy. These GHGs include: carbon dioxide (CO2) (from burning fossil fuels), methane (CH_4), nitrous oxide (N_2O) (created by agriculture, land use and changes in land use where these gases are emitted), ozone (O_3) (generated mostly by fumes from car exhausts) and chlorofluorocarbons (CFCs). The increase of these GHGs in the atmosphere further prevents infrared radiation escaping from the earth’s atmosphere into space, causing what is called ‘global warming’. This acceleration of global warming by humans is referred to as the enhanced greenhouse effect or anthropogenic climate change [12].

1.8 ROLE OF DIESEL ENGINE IN INDIAN ECONOMY

Diesel Engine plays a very important role in Indian economy and also contributes to pollution significantly. These engines is used in heavy trucks, city transport buses, locomotives, electric generators, farm equipment, underground mine equipment etc [13, 14]. The dual problem of fast depletion of petroleum based fuels and air pollution can be judiously handled by switching from fossil fuel based economy to renewable source of energy. Our country is an agriculture based economy and agriculture is an energy transformation process as energy is produced and consumed in it. The production of energy is carried through process of photosynthesis in which solar energy is converted into biomass. Agriculture in India is heavily based upon petroleum and its derived products such as fertilizers and pesticides. Energy sources used in agriculture are oil and electricity whereas indirect energy sources are chemical fertilizers and pesticides.

Oil and electricity are two major fuels which are used in agriculture sector. Because of mechanized farming the amount of energy consumed has increased multifold since independence in terms of oil and electricity.

1.9 ALTERNATIVE FUELS FOR COMPRESSION IGNITION ENGINE

With the indispensable position gained by diesel engine in recent years, the demand for conventional fuel and environmental degradation caused by fossil diesel combustion cannot be underestimated. As already elaborated, alternative fuels are immediately needed to deal the dual problem of fast depletion of fossil fuel reserves and environmental pollution. Such fuels should be renewable, should be suitable for use in existing engines and associated systems (such as fuel tank, pumps and hoses) as well other existing fuel storage, transportation and retail infrastructure. Since diesel engine plays an important and indispensable role in Indian economy and various sector of the country, fuels of bio-origin can provide a feasible solution to the problem.

Some of these fuels can be used directly while others need to be transformed to bring the relative properties close to the conventional fuels. Ethanol is an attractive alternate liquid source for I.C engines since it can be produced from renewable sources such as grains [15]. Given the widespread use of diesel fuels, in various sectors, the study on the performance of vegetable oils when used as a fuel in the neat or blended form is desirable [16]. Since the viscosity of vegetable oils, hence of the fuel is of prime concern, the reduction in the viscosity is required which can be carried out by transesterification process [17].

1.10 NECESSITY OF ALTERNATIVE FUELS

It is clear from the above discussions that India is facing the twin problems of fast depletion of fossil fuels and environmental degradation. There is an urgent need to reduce dependence on petroleum derived fuels for better economy and environment. Adaptation of bio-origin alternative fuels can address both these issues. These fuels are essentially non-petroleum and result in energy security and environmental benefits. These fuels are available either in one form or other for more than one hundred years. Before the introduction of gasoline as a motor fuel in the late 1800s, vehicles were often powered by what are now considered alternative fuels. The first internal combustion engine designed, built, and demonstrated by Rudolf Diesel at the 1900 Paris World’s Fair ran on peanut oil. This was the product of his dream – an efficient internal combustion engine, powered by crude oil or even vegetable oil.

Identification of alternative fuels for use in I.C. Engines has been subjected to studies throughout the globe. Performance tests have shown suitability of variety of alternative fuels such as hydrogen, alcohols, biogas, producer gas and various types of edible and non edible oils. However, in Indian context, the bio-origin fuels like alcohols, vegetable oils, and biogas can contribute significantly towards the problems related to fuel crises.

1.11 PRESENT WORK

In context to present work, a more elaborate discussion on adaptation of 1-octanol is made. Octanol is a promising fuel, particularly for diesel engines. The practicality of octanol blended with diesel fuels has been sufficiently demonstrated to warrant further investigation of their effectiveness and to develop techniques that will permit their incorporation [21]

This study investigates the effects of octanol-blended diesel on CI engine at varying load conditions. Blend of oxygenated alcohol fuels to diesel has drawn great attention as a way to promote the use of bio-derived alternative fuels and for reduction of soot emissions in direct-injection diesel engines. This study compares the mixture condition, combustion and sooting characteristics of octanol–diesel blends to those of a diesel

The analysis that follows will primarily focus on the two most influential diesel engine pollutants, PM and NO_x, but results will be also presented for the other two regulated pollutants CO and HC. The target of the present work is to review the literature regarding the impacts of diesel-biodiesel blends on the (regulated exhaust) emissions of compression ignition engines under the very critical transient conditions encountered in the every-day engine/vehicle operation i.e., acceleration, load increase, starting and in the collective form of transient cycles.

CHAPTER 2

LITERATURE REVIEW

This study investigates the effects of octanol-blended diesel on CI engine at varying load conditions. Blend of oxygenated alcohol fuels to diesel has drawn great attention as a way to promote the use of bio-derived alternative fuels and for reduction of soot emissions in direct-injection diesel engines. This study compares the mixture condition, combustion characteristics of octanol–diesel blends to those of a diesel.

Oxygenates produce a significant reduction in emissions of particulate matter from diesel engines but in most cases also causes the nitrogen oxide emissions to increase.

The analysis focuses on all regulated pollutants, i.e. particulate matter, nitrogen oxides, carbon monoxide and unburned hydrocarbons. The most important mechanisms of exhaust emissions during transients are analyzed based on the fundamental aspects of transient operation and on the impacts the physical and chemical properties of octanol-diesel blends have relative to conventional diesel oil.

The performance and exhaust emissions such as unburned hydrocarbons [UBHC], carbon monoxide [CO], carbon-dioxide [CO_2] and nitric oxide [NO] were measured from the diesel engine at different power outputs. The emission tests found that the CO and HC slightly increased, while O_2 decreased moderately and NOx appreciably increased, however it decreased after applying the load above 60 %. In addition, combustion analyses were made with the help of combustion analyzer, in which cylinder pressure and heat release rate were analyzed.

2.1 INTRODUCTION

Diesel engine power plants are preferred where power has to be generated in small quantity or used as standby sets which are required for commercial use. In many countries the demand of fuel for diesel engines increases for much use in agriculture, transportation and power generation. But, on account of high fuel consumption of diesel fuel the need for replacement of diesel fuel became essential.

The present work reviews the literature concerning the effects of alcohol/diesel blends on the exhaust emissions of diesel engines operating under transient conditions, i.e., load increase, starting and transient/driving cycles. The analysis focuses on all regulated pollutants, i.e. particulate matter, nitrogen oxides, carbon monoxide and unburned hydrocarbons. The most important mechanisms of exhaust emissions during transients are analyzed based on the fundamental aspects of transient operation and on the impacts the physical and chemical properties of octanol blend diesel have relative to conventional diesel oil.

The analysis that follows will primarily focus on the two most influential diesel engine pollutants, PM and NO_x, but results will be also presented for the other two regulated pollutants CO and HC

2.2 Octanol as a Blend in Diesel

The term n-Octanol usually refers to the isomer, octan-1-ol, with the molecular formula $CH_3(CH_2)_7OH$. It is a fatty alcohol. Many other isomers are also known. Esters of octanol, such as octyl acetate, occur as components of essential oils. Octanol is manufactured for the synthesis of esters for use in perfumes and flavorings. It is used to model the partitioning of pharmaceutical products between water and the cytosol. Other uses include experimental medical procedures for controlling Essential Tremor and other types of involuntary neurological tremors.

Octanol is produced industrially by the oligomerization of ethylene using triethylaluminium followed by oxidation of the alkylaluminium products.[2] An idealized synthesis is shown:

$$Al(C_2H_5)_3 + 9\ C_2H_4 \rightarrow Al(C_8H_{17})_3$$

$$Al(C_8H_{17})_3 + 3\ O + 3\ H_2O \rightarrow 3\ HOC_8H_{17} + Al(OH)_3$$

The process generates a range of alcohols that are separated by distillation.

Octanol and water are immiscible. The distribution of a compound between water and octanol is used to calculate the partition coefficient 'P' of that molecule (often expressed as its logarithm to the base 10, log P). Water/ octanol partitioning is a relatively good approximation of the partitioning between the cytosol and lipid membranes of living systems.

Table 2.1 shows the various physical properties of 1-octanol which I have used as a blend in diesel in my work.

Table: 2.1 Properties of 1-Octanol

Physical Properties	**1-Octanol ($C_8H_{18}O$)**
Molar Mass	130.23 g/mol
Density	0.824 g/cm^3
Melting Point	-16^0C, 257 k, 3^0F
Boiling Point	195^0C, 468K, 383^0 F
Solubility in Water	Insoluble

2.3 LITERATURE REVIEW

Qi et al. investigated performance and combustion characteristics of biodiesel-methanol-diesel blends in compression ignited engines. 50% biodiesel and 50% diesel fuels (BD50) were

prepared as the baseline fuel. Also, methanol was added to BD50 as an additive with volume percent of 5% and 10% (BDM5 and BDM10). Results indicated that BDM5 and BDM10 show a significant decrease of smoke emissions, while CO emissions are slightly lower. NOx and HC emissions were almost similar to those of BD50, at full load.

Shi et al. used ethanol-biodiesel-diesel fuel blends with the blend ratio of 5% ethanol 20% methanol75% diesel fuel by volume. Biodiesel-ethanol-diesel showed a significant reduction in particulate matter (PM) emissions and a 14% increase of NOx emissions.

J. Campos-Fernández et al. compared the short-term performance of a direct injection diesel engine fueled with different 1-butanol/diesel and 1-pentanol/diesel fuel blends, without any modifications of the engine. Experimental results showed a slight engine power loss and an increase in brake thermal efficiency when the engine was fueled with higher alcohols blends instead of straight diesel fuel.

Agarwal.et.al. studied Ethanol as an attractive alternative fuel because it is a renewable bio-based resource and it is oxygenated, thereby providing the potential to reduce particulate emissions in compression-ignition engines. The effect of intake charge dilution on the combustion and emissions of alcohol-biodiesel blends were investigated on a four cylinder direct injection diesel engine at two engine loads of 0.2 and 0.46 MPa. With the increase of intake CO_2 concentration, CO and HC emissions increase for all the tested fuels. At each intake CO_2 concentration, the CO and HC emissions are reduced for the blended fuels.

Z. Zhang et al Combustion characteristics of methanol–air and methanol–air– diluent mixtures at different equivalence ratios, initial pressures and temperatures, and dilution ratios are studied. The methanol–air mixtures slightly richer than stoichiometric equivalence ratio give the peak combustion pressure, peak mass burning rate and burned gas temperature give their maximum values at the equivalence ratio of 1.1

Adailehet et. al. presented the combustion and emissions characteristics of blended oil diesel at variable engine speed between 1200-2600 rpm. The results showed significant reductions in CO, and unburned HC, but the NOx was increased. Biodiesel has a 5.95 % increase in brake-specific fuel consumption. The fuel consumption rate, brake thermal efficiency, and exhaust gas temperature increased while the BSFC, emission indices of CO_2, CO decreased with an increase of engine speed.[43]

Hulwan.et.al. Jatropha derived biodiesel (methyl ester) addition, in adequate quantity, in the blends of diesel and ethanol, drastically improved the solubility of ethanol in diesel fuel. The comparison of blend results with baseline diesel showed that brake specific fuel consumption increased considerably, thermal efficiency improved slightly, smoke opacity reduced remarkably at high loads.

X. Shi et al. studied the emission characteristics of a Cummins-4B diesel engine using biodiesel–ethanol–diesel fuel blends were investigated and compared with those using diesel fuel. The application of BE-diesel can reduced PM emissions by 30% in average. However, BE-diesel did lead to a slight increase of NOx emissions in a range of 5.6–11.4% at tested conditions.

Lu¨ et al., 2004;Ethanol is a low cost oxygenate with high oxygen content (35%) that has been used in ethanol–diesel fuel blends. The use of ethanol in diesel fuel can yield significant reduction of particulate matter (PM) emissions for motor vehicles.

Fernando.et.al. reported that the ethanol–biodiesel–diesel fuel blends are stable well below sub-zero temperature and have equal or superior fuel properties to regular diesel fuel.

Makareviciene et al. (2005) characterized the solubility of biodiesel fuel components in fossil diesel–methanol–rapeseed oil methyl ester, fossil diesel–ethanol–rapeseed oil methyl ester and fossil diesel–ethanol–rapeseed oil ethyl ester systems. They also proved that addition of ester to
ethanol and fossil diesel fuel mixture increases solubility of ethanol in diesel fuel. The low flashpoint of ethanol–diesel blend is a technical barrier to the application of this fuel blend.

Mccormick.et.al. worked on several oxygenates having a wide range of properties were blended with no. 2 diesel at the 1 and 2 wt % oxygen level. Emissions were measured using the hot start portion of the U.S. Heavy-Duty Transient Test (40 CFR, Part 86, Subpart N) in both a 2-stroke and a 4-stroke engine. It was found that at this oxygen level PM reductions on the order of 10-15% were obtained regardless of oxygenate chemical structure. The oxygenates affected the integrated NOx emissions differently.

Altun et.al. conducted experimental work to evaluate the effects of using normal butanol, fossil derived diesel fuel and bio diesel blends to have a comparative analysis of engine's performance and exhaust emissions of a single cylinder direct injection diesel engine. The experiments were conducted on a constant speed engineand at three different engine loads.

Results showed that BSEC of B20 (20% cotton seed bio-diesel and 80% diesel by volume) was higher as compared to that of conventional diesel fuel. Exhaust emission like CO and UBHC were reduced

Laza et.al. had studied the role of various alcohols including 1-propanol, 2-praponol, isobutanol and 2-butanol in a diesel engine when blended with vegetable oil.it was concluded from the studythat these alcohols can be blended with vegetable oil. The results indicated that the viscosity, CPFF, density, cetane number and heating value of the blends decrease with an increase in concentration of alcohols in the blends. These blends were having higher flash points than mineral diesel, hence making them much safer than normal diesel fuels in terms for safety in storage and transportation.

2.4 STATEMENT OF A PROBLEM

There is a growing interest on using alcohols to substitute diesel fuel, as the use of oxygenated fuels involves oxygen enrichment, enhancement of premixed combustion phase and improvement of the diffusive combustion phase [12]. However, some difficulties prevent their use as fuel for diesel engines:

To check the solubility of the higher carbon chain of an alcohol like 1-octanol in this report with diesel.

As the experimental tests have rarely been done on higher C-chain alcohols blended with diesel, so here an effort has been made in the report whether diesel engine without any modification can run on diesel blended with 1-octanol. Also, the tests have been performed to check the various performance characteristics and emission characteristics of the same.

Lower alcohols (ethanol and methanol) have been widely studied as alternate fuels, although they depict solubility problems in diesel fuel [2,11]. Moreover, percentages of ethanol above 10% blended with diesel fuel usually reduce engine power [7,12,13]] and increase brake specific fuel consumption (BSFC) [1,2,7,14].

However, the experiments done clearly indicate that there is substantial reduction in particulate emissions through the addition of oxygenates to diesel fuel. Also, there is an increase in break thermal efficiency and decrease in BSFC with the increase in the percentage of 1-octanol.

CHAPTER 3

SYSTEM DEVELOPMENT & EXPERIEMNTAL PROCEDURE

3.1 INTRODUCTION

Diesel engines are widely used for various purposes, e.g., for driving automobiles, ships and construction machines, and are still spreading further. As a result, fuel for diesel engines is increasingly in demand and becoming heavier to satisfy the increased demands, because straight-run diesel fuel oil is distilled deeper and/or blended with heavier fractions. This is accompanied by several problems, e.g., deteriorated fluidity at low temperature (i.e., increased pour point and/or cold flow plugging point). It is anticipated, therefore, that several engine troubles, e.g., plugging of fuel passage or fuel filter, may occur regionally in a normal temperature range at which the engine is operated in some districts.

Several measures against deteriorated fluidity of diesel fuel oils at low temperature have been proposed to provide fuel oils having adequate pour point and cold flow plugging point (CFPP) properties for temperature conditions, in particular in cold districts. These measures include limitation on end point of straight-run diesel oil, limitation on use of heavier fractions as the blending stocks, use of lighter blending stocks, and use of adequate additives, e.g., fluidity improver, including pour point depressant and FI, to improve e.g., fluidity improver, including pour point depressant and FI, to improve fluidity at low temperature.

3.2 PHYSICO-CHEMICAL PROPERTIES

3.2.1 Density

Density is the mass per unit volume. The measurement was made at room temperature. The density was measured with the help of a U-Tube Oscillating True Density meter. The density of blend was measured and then compared with that of diesel fuel. For various blends the density at 15^0C is given in Table 3.1

Table 3.1 Density for various octanol-diesel blends

BLEND	**OC 5**	**OC 10**	**OC 15**	**OC 20**
DENSITY (g/cm^{3})	0.82222	0.82301	0.82320	0.82418

Plate 3.1: U-Tube Oscillating True Density Meter

3.2.2 Viscosity

When a fluid is subjected to external forces, it resists flow due to internal friction. Viscosity is a measure of internal friction. The viscosity of the fuel affects atomization and fuel delivery rates. It is an important property because if it is too low and too high then atomization and mixing of air and fuel in combustion chamber gets affected. Viscosity studies were conducted for different test fuels. Absolute viscosity sometimes called dynamic or simple viscosity is the product of Kinematic viscosity and fluid density. Kinematic viscosity of liquid fuel samples were measured using Kinematic viscometer shown in fig. 3.2 at 40^0 C as per the specification given in ASTM D445. A suitable capillary tube was selected, and then a measured quantity of sample was allowed to flow through the capillary. Efflux time was measured for calculating Kinematic viscosity using the formula given below:

$\nu = c^* t$ … (3.1)

Where,

ν = Kinematic viscosity, cSt or mm^2/sec

k = 0.009427 mm^2/sec^2 ;constant

t = time, sec

Table 3.2 Viscosity for various octanol-diesel blend

BLEND	OC 5	OC 10	OC 15	OC 20
VISCOSITY cs	2.903516	3.073202	3.20518	3.459709

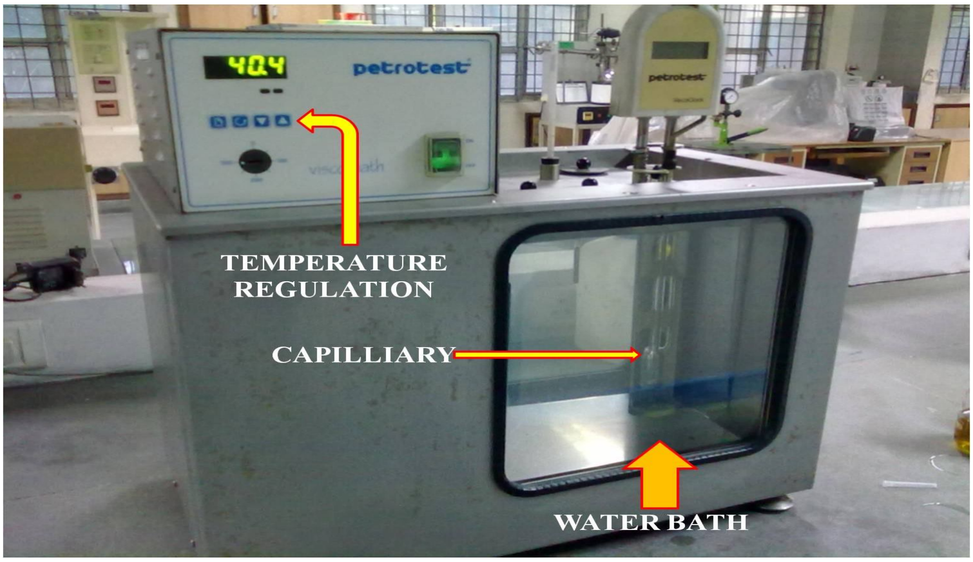

Plate 3.2: Kinematic Viscometer

3.2.3 Calorific Value

The calorific value is defined in terms of the number of heat units liberated when unit mass of fuel is completely burnt in a calorimeter under specified conditions. Higher calorific value of fuel is the total heat liberated in kJ per kg or m^3. All fuels containing hydrogen in the available form will combine with oxygen and form steam during the process of combustion. If the products of combustion are cooled to its initial temperature, the steam formed as a result will condense. Thus maximum heat is abstracted. This heat value is called the higher calorific value.

The calorific value of the fuel was determined with the Bomb Calorimeter as per the specification given in Parr 6100. The combustion of fuel takes place at constant volume in a totally enclosed vessel in the presence of oxygen. The sample of fuel was ignited electrically. Then the fuel samples were burnt in bomb calorimeter and the calorific value of all samples were calculated. The Bomb Calorimeter used for determination of Calorific value is shown in Plate.3.3.

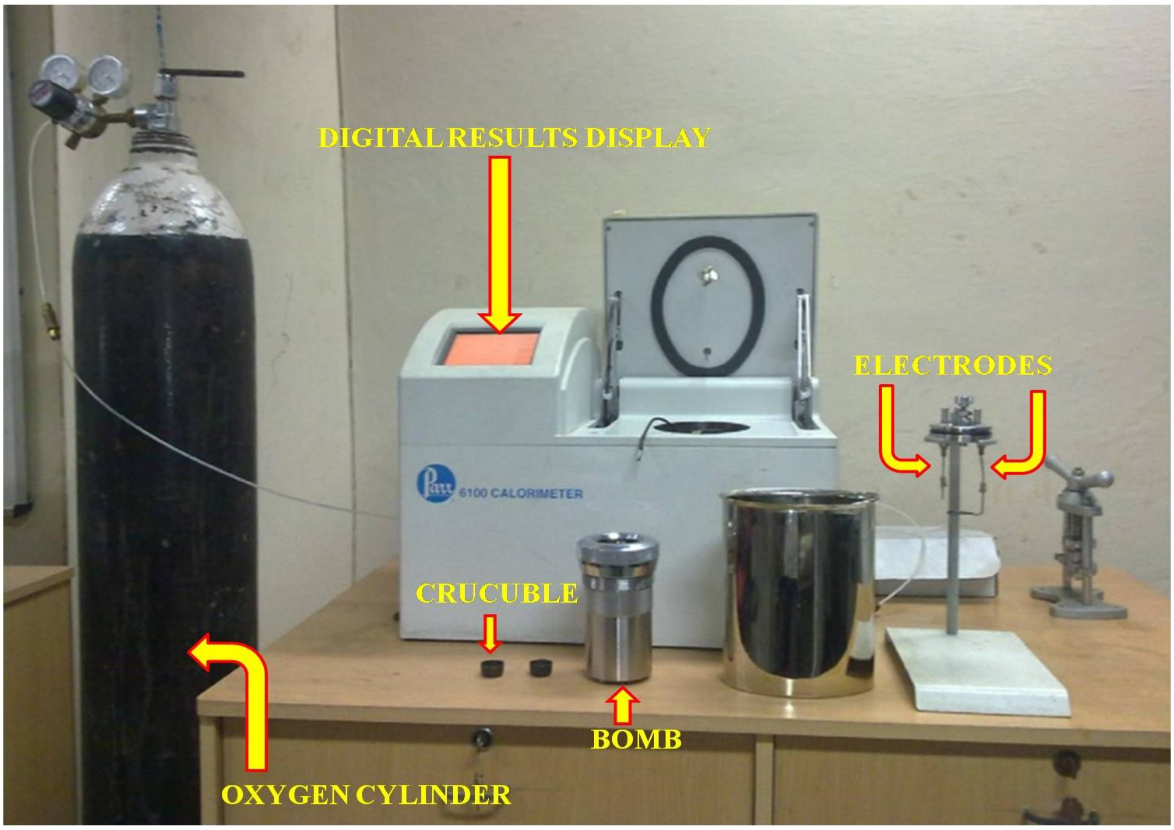

Plate 3.3: Bomb calorimeter

The heat of combustion of the fuel samples was calculated with the help of equation given below:

$H_c = (W_c T)/ M_s$ … (3.2)

Where,

H_c = Heat of combustion of the fuel sample, kJ/kg

W_c = Water equivalent of the calorimeter assembly, kJ/ ^oC

T = Rise in temperature, ^oC

M_s = Mass of sample burnt, Kg

3.2.4 COLD FILTER PLUGGING POINT (CFPP)

Cold Filter Plugging Point (CFPP) is defined as the minimum temperature at the fuel filter does not allow the fuel to pass through it. At low operating temperature fuel may thicken and does not flow properly affecting the performance of fuel lines, fuel pumps and injectors. Cold filter plugging point of the blend reflects its cold weather performance. It defines the fuels limit of filterability. The apparatus for CFPP measurement is shown in Plate.3.4

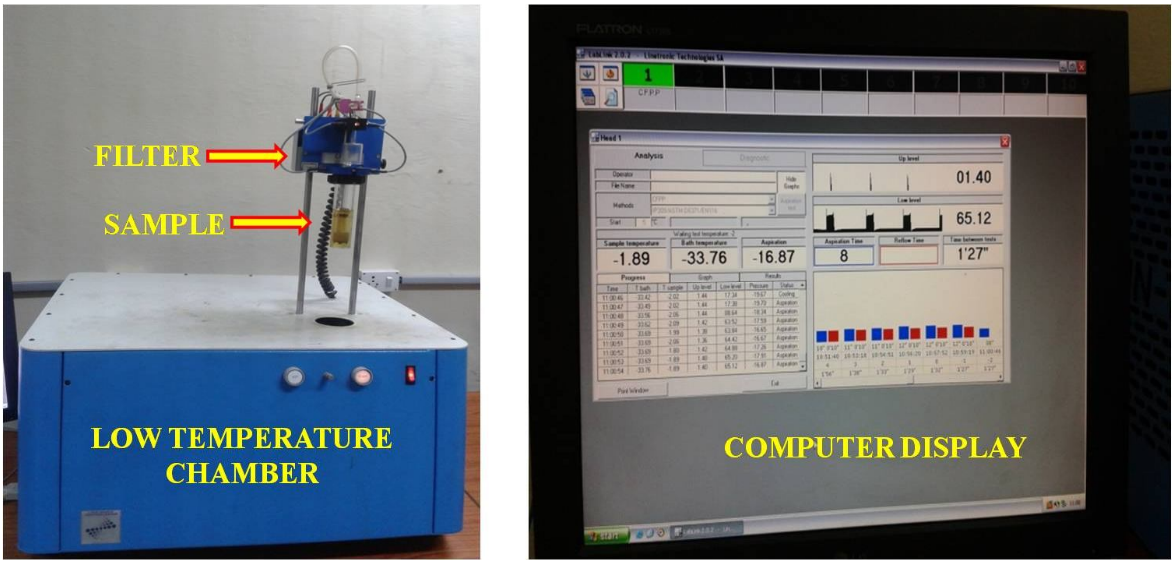

Plate.3.4: Cold Filter Plugging Point Apparatus

3.3 ENGINE SELECTION

In today’s world, there is no difference of opinion that India is going to face a severe fuel crisis in future because fuel consumption has increased in all the vital sectors specially transportation and agricultural sector. As diesel engines plays an indispensable role in transportation and agriculture sector and as such diesel consumption will increase multifold in time to come. The diesel engine continues to dominate the agriculture sector in our country in comparison to spark ignition engine and have always been preferred widely because of power developed, specific fuel consumption and durability. However, it would be worthwhile to inform that the fuel is burnt in diesel engine by self ignition at higher temperature and pressure conditions of the order of 600°C and 40 bar, respectively. Diesel as a fuel is injected into the combustion chamber at the end of compression stroke and after certain ignition delay; it burns to give the motive power. In India, almost all irrigation pump sets, tractors, mechanized farm machinery and heavy transportation vehicle are powered by direct injection diesel engines. Keeping the specific features of diesel engine in mind, a typical engine system, which is actually used widely in the Indian agricultural sector, has been selected for the present experimental investigations.

3.4 DEVELOPMENT OF AN EXPERIMENTAL TEST RIG

A Kirloskar make, single cylinder, air cooled, direct injection, DAF 8 model diesel engine was selected for the present research work, which is primarily used for agricultural activities and household electricity generations as shown in Plate. 3.5.

It is a single cylinder, naturally aspirated, four stroke, vertical, air-cooled engine. It has a provision of loading electrically since it is coupled with single phase alternator through flexible coupling. The engine can be hand started using decompression lever and is provided with centrifugal speed governor. The cylinder is made of cast iron and fitted with a hardened high-phosphorus cast iron liner.

Plate. 3.5: Test Engine

The lubrication system used in this engine is of wet sump type, and oil is delivered to the crankshaft and the big end by means of a pump mounted on the front cover of the engine and driven from the crankshaft. The inlet and exhaust valves are operated by an overhead camshaft driven from the crankshaft through two pairs of bevel gears. The fuel pump is driven from the end of camshaft. The detailed technical specifications of the engine are given in Table 3.3.

Table 3.3: Specifications of the Diesel Engine

Make	Kirloskar
Model	DAF 8
Rated Brake Power (bhp/kW)	8 / 5.9
Rated Speed (rpm)	1500
Number of Cylinder	One
Bore X Stroke (mm)	95 x 110
Compression Ratio	17.5:1
Cooling System	Air Cooled (Radial Cooled)

Lubrication System	Forced Feed
Cubic Capacity	0.78 Lit
Inlet Valve Open (Degree)	4.5 BTDC
Inlet Valve Closed (Degree)	35.5 ABDC
Exhaust Valve Open (Degree)	35.5 BBDC
Exhaust Valve Closed (Degree)	4.5 ATDC
Fuel Injection Timing (Degree)	26 BTDC

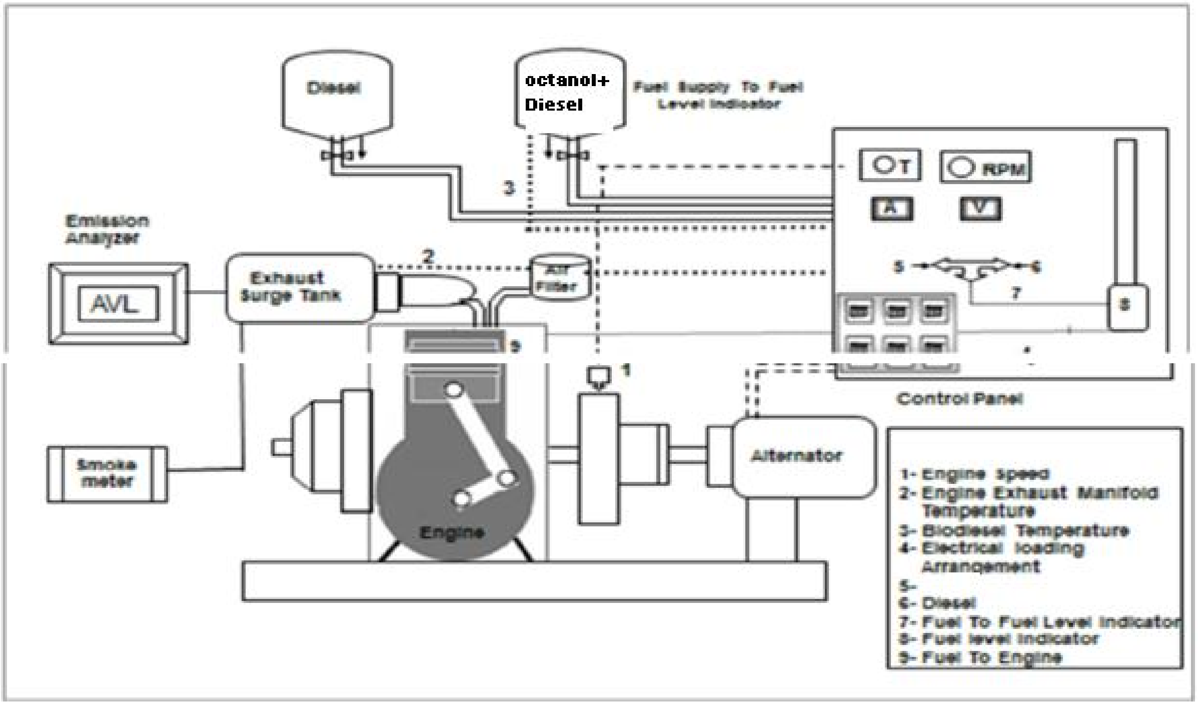

Fig. 3.6 Schematic Diagram of the Experimental Set Up

3.5 INSTALLATION OF THE INSTRUMENT CONTROL PANEL

After finalizing the procedures for data collection and procurement of the desired instruments, they were put on a panel. A stand was fabricated and a 1020mm×850mm bakelite sheet of 3-mm thickness was mounted on it. Instruments such as voltmeter, ammeter, speed counter, four channels digital temperature display was mounted on the front side of the control panel (Plate. 3.6). Electrical load banks, i.e., 12 bulbs each of 500 watts, were mounted on the rear side of the control panel which is shown in Plate.3.7 and their switches provided on the front side of the control panel.

Plate 3.6: Control Panel (front side)

Plate 3.7: Load Bank (rear side)

One burette with stop cocks and two way valves were also mounted on the front side of the panel for fuel flow measurements and selecting between either diesel fuel or octanol-diesel blend. The two fuel tanks were mounted on the rear side of the panel at highest position as shown in Plate.3.8.

Fig. 3.8: Two Tanks System

A voltmeter, ammeter and wattmeter were connected between alternator and load bank. A nut was welded on the flywheel and the photo reflective sensor was mounted on a bracket attached to engine body. The thermocouples were mounted in the exhaust manifold to measure the exhaust temperature. The AVL 437 smoke meter and AVL Di Gas Analyzer were also kept in proximity for the measurements of various exhaust gas parameters.

Thus such a system was chosen to examine the practical utility of the blend oil in such applications. Besides being a single cylinder system it was light and easy to maintain. The engine was provided with suitable arrangement, which permitted wide variation of controlling parameters. Being an air cooled engine it was suitable for hot climate. Absence of radiator, water body and pump made the system more suitable for the tests.

3.6 PARAMETERS SELECTION

The selections of appropriate parameters were essential for engine calculations, and parameters were selected very judiciously. The engine test was done as specified by IS: 10000. The main parameters desired from the engine are listed below.

1. Power produced by the engines

2. Engine speed (Rev/min)
3. Fuel consumption
4. Temperature
5. Speed of the engine

With a view to calculate the parameters mentioned above, it was essential to pick up the following signals from the test bench.

1. Voltage generated by the alternator
2. Current generated by the alternator
3. RPM of the engine
4. Exhaust gas temperature
5. Fuel consumption rate
6. AVL 437 smoke meter
7. AVL Di Gas analyzer

Once the parameters were selected, the essential instruments required for sensing these parameters were installed at the appropriate points in the experimental set-up.

3.7 MEASUREMENT METHODS

As already elaborated, the main components of the experimental setup are two fuel tanks (Diesel and octanol-diesel blend), bypass line, Fuel consumption measuring unit, Electrical loading arrangement, voltmeter, ammeter, RPM meter, Temperature indicator and emissions measurement equipments. The engine is started with diesel for at least 30 minutes and once the engine warms up, it is switched over to octanol-diesel blend. For switching the engine from diesel to octanol-diesel blend, a two way valve is provided on the control panel. Both the fuels from the two tanks can be feed to the engine through this valve separately. One end of the valve is connected to octanol-diesel blend and the other end is connected to diesel. The fuel from the valve enters into the engine through this fuel measuring unit. With the help of this fuel measuring unit, the volumetric flow of the fuel can be easily measured. The fuel from the fuel measuring unit then enters in to the fuel filter before entering to the engine.

3.7.1 Fuel Flow Measuring System

The fuel consumption of an engine is measured by determining the time required for consumption of a given volume of fuel. The mass of fuel consumed can be determined by multiplication of the volumetric fuel consumption to its density. In the present set up volumetric fuel consumption was measured using a glass burette. The time taken by the engine to consume a fixed volume of 10cc was measured using a stopwatch. The volume divided by the time taken for fuel consumption gives the volumetric flow rate. The test facilities were built up for measuring both diesel and octanol diesel blend consumption rates. For this, two separate tanks, one burette, and a number of valves were provided on the panel as shown in the Plate. 3.9.

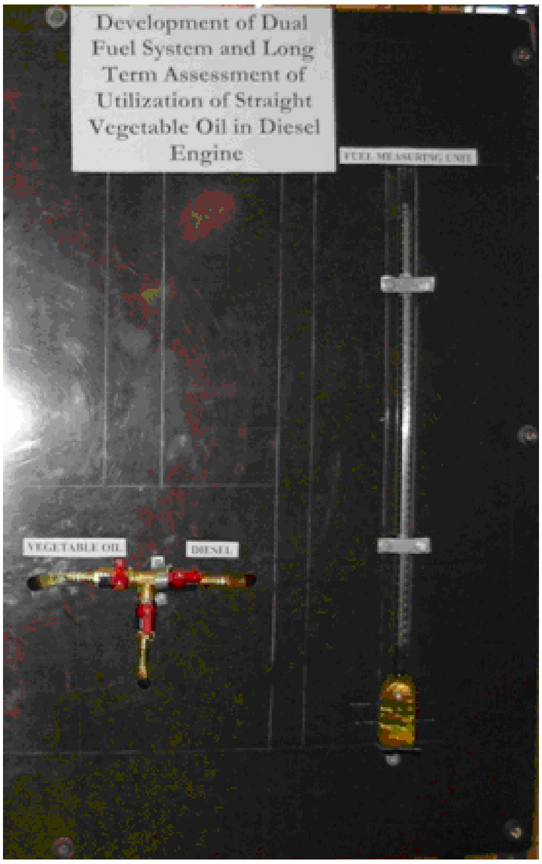

Plate. 3.9: Fuel Flow Measuring System

This test was carried out only after the preliminary run. After stable operating conditions were experimentally achieved, the engine was subjected to similar loading conditions. Starting from no load, observations were recorded at 20%, 40%, 60%, 80% and 100% of the rated load.

The brake specific fuel consumption was calculated by using the relationship given below:

$bsfc = (Vcc \times \ell \times 3600) / (hp \times t)$ (3.3)

Where, bsfc = Brake specific fuel consumption, g/kW-h

Vcc = Volume of fuel consumed, cc

ℓ = Density of fuel, g/cc

hp = Brake horsepower, kW

t = Time taken to consume, cc of fuel, sec.

The brake thermal efficiency of the engine on different fuel blends at different operating conditions was determined using the equation as given below:

$\eta_{th} = Ks / (HV \times bsfc)$ (3.4)

Where, η_{th} = Brake thermal efficiency, %

Ks = Unit constant, 3600

HV = Gross heat of combustion, kJ/kg

bsfc = Brake specific fuel consumption, g/kW-h

3.7.2 Temperature Measurement

Chromel-Alumel K-type thermocouples were connected to a 6 channel digital panel meter to measure temperatures of exhaust gas. Temperature of octanol diesel blend is also observed at various points. The meter was calibrated by a millivolt source up to 800 ^{o}C. Table 3.4 shows the exhaust temperature of various octanol diesel blends at different loads

Table 3.4 Exhaust temp. of various blends at different loads.

LOAD (%)	**OC 5 (^{o}C)**	**0C 10 (^{o}C)**	**0C 15 (^{o}C)**	**0C 20 (^{o}C)**
0	170	175	168	175
20	220	224	224	222
40	288	286	286	281
60	331	359	363	351
80	431	438	445	430
100	457	414	481	477

3.7.3 Exhaust Emission Analysis

The major pollutants appearing in the exhaust of a diesel engine are the oxides of nitrogen. Exhaust gas analysis was done for exhaust smoke opacity, UBHC, CO, CO_2 and NOx. For measuring the smoke opacity, AVL 437 smoke analyzer was utilized. This instrument gave reading in terms of percentage opacity. Of the light beam projected across a flowing stream of exhaust gases, a certain portion of light is absorbed or scattered by the suspended soot particles in the exhaust. The remaining portion of the light falls on a photocell, generating a photoelectric current, which is a measure of smoke density

For measurement of UBHC, CO, CO_2 and NOx, AVL 4000 Light Di-Gas Analyzer was used. The detailed specification of AVL Di-gas Analyzer has been given in Appendix II. Both the AVL 437 Smokemeter and AVL Di Gas Analyzer are shown in Plate.3.10

Plate. 3.10 Smoke and Emissions Measuring System

3.8 EXPERIMENTAL PROCEDURE

The engine was started at no load by pressing the exhaust valve with decompression lever and it was released suddenly when the engine was hand cranked at sufficient speed. After feed control was adjusted so that engine attains rated speed and was allowed to run (about 30 minutes) till the steady state condition was reached. With the fuel measuring unit and stop watch, the time elapsed for the consumption of 10cc of fuel was measured for OC5, OC10, OC15 and OC20 at varying load. Fuel Consumption, RPM, exhaust temperature, smoke density, CO, NO_x, HC , CO_2 and power output were also measured. The engine was loaded gradually keeping the speed with in the permissible range and the observations of different parameters were evaluated. Short term performance tests were carried out on the engine with diesel to generate the base line data and subsequently blend was used to evaluate its suitability as a fuel. The performance and emission characteristics of the blend oil were evaluated and compared with diesel fuel The engine was always started with diesel as a fuel and after it was run for 20-25 minutes, it was switched over to Octanol diesel blend. Before turning the engine off, the octanol diesel blend was replaced with diesel oil and it was run on diesel oil till all octanol diesel blend in fuel filter and pipe line was consumed.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 INTRODUCTION

The present study was done on an unmodified diesel engine. The main objective of the study was to fuel a diesel engine with octanol diesel blend and evaluate the performance and emission characteristics at different loads and compare the results with baseline data. Compared to other alcohols, octanol seems to be most attractive alternative to partly substitute diesel fuel because it provides properties values similar to those of diesel fuel. Hence, compared to alcohols like methanol or ethanol, a better performance is expected.

4.2 COMPARISON OF PHYSICO-CHEMICAL PROPERTIES BETWEEN DIESEL AND OCTANOL DIESEL BLEND

Both the fuels Diesel oil and octanol diesel blend oil were analyzed for several physical, chemical and thermal properties. Density of octanol diesel blend was found higher than diesel. Octanol diesel blend is extremely safe to handle. Presence of oxygen in fuel improves combustion properties and emissions but reduces the calorific value of the fuel. Nitrogen content of the fuel also affects the NO_x emissions (by formation of fuel NO. Viscosity of octanol diesel blend was measured at 40°C and found to be approximately of the same value as that of diesel.

The Various Physico-chemical properties of Diesel and octanol diesel blend are given in Table 4.1

Table 4.1: Physico-Chemical Properties of Diesel and Octanol Diesel blend

Property	Mineral Diesel	Octanol Diesel blend
Density(kg/m^3)	810	823.56
Kinematic Viscosity at 40°C (cSt)	2.5	3.387
Cold Filer Plugging Point (CFPP) (°C)	-13	-10
Calorific value (kJ/kg)	42,200	37634.68

4.3 PERFORMANCE CHARACTERISTICS

4.3.1 Brake Thermal Efficiency

Fig. 4.1 shows the variation of different octanol diesel blends in comparison to neat diesel. It is clear that the Brake Thermal Efficiency (BTE) first increase with increase in load and thereafter it decreases. It is also found that BTE is increasing with increasing volume of octanol in octanol diesel blends. The maximum BTE observed for the blends OC 5, OC 10, OC 15 and OC 20 are 24.46%, 25.59%, 26.19% and 27.02% respectively. The maximum BTE in case of neat diesel is 23.71%. The increase in BTE with addition of octanol in diesel may be due to the fact that octanol is oxygenated which results in improved combustion. Moreover, addition of octanol in diesel also reduces kinematic viscosity which makes atomization better. These two factors leads to the increased BTE. The results are similar to the results obtained by O.Dogan [43] and Rakapoulus [44].

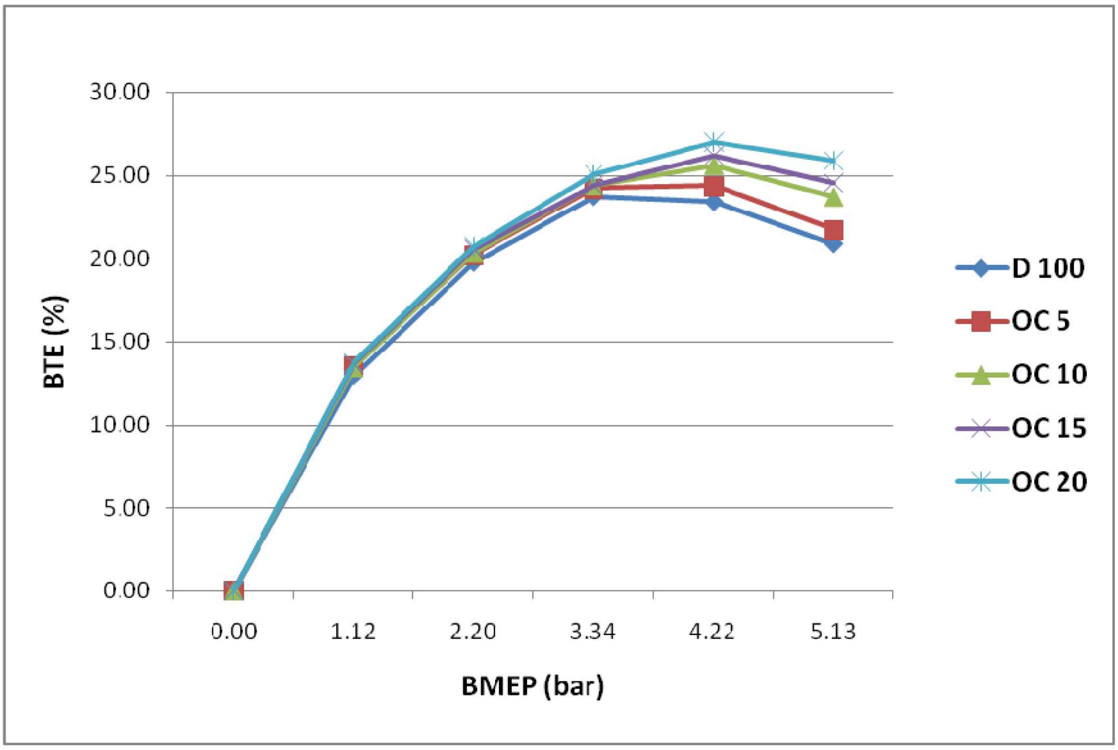

Fig. 4.1 BTE v/s BMEP

4.3.2 Brake Specific Energy Consumption

Since Brake Specific Fuel Consumption (BSFC) is not a very reliable parameters to compare the performance of two different fuels since density and calorific value of both the fuel are significantly different. Therefore, brake specific energy consumption (BSEC) was taken as a parameter to compare the energy requirement for producing unit power in case of different test fuels.

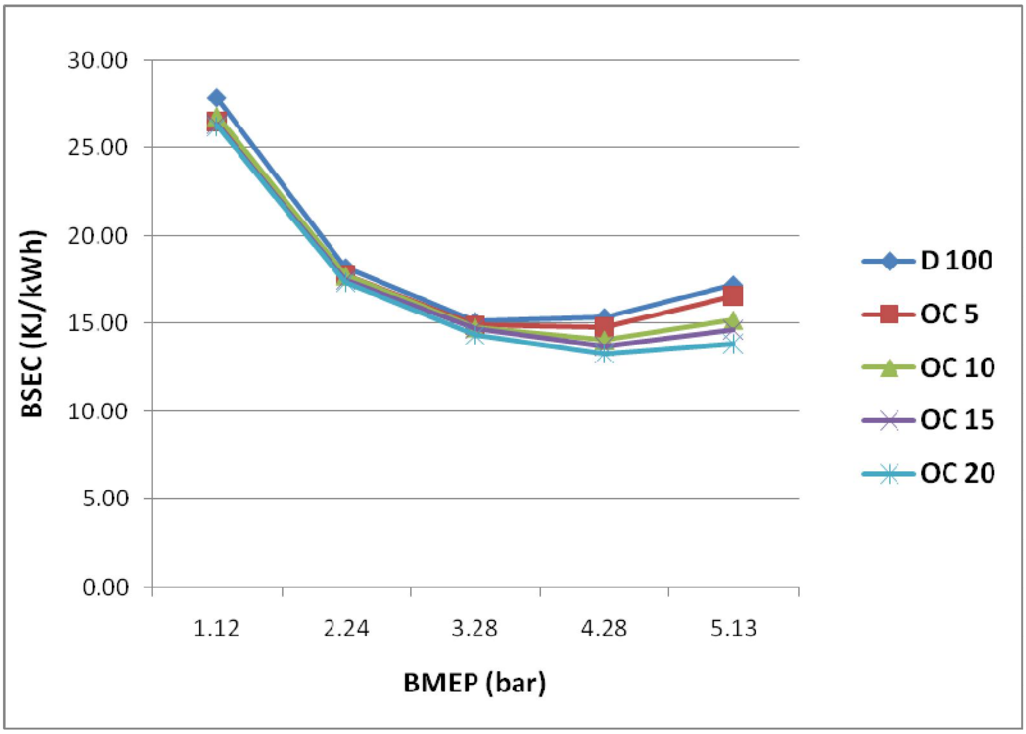

Fig 4.2: BSEC v/s BMEP

As seen from the Fig. 4.2, the BSEC reduces with the increase in BMEP. BSEC of the octanol-diesel blend is lower than the baseline data for the neat diesel. This is mainly because of presence of oxygen in octanol which helps in better combustion. Due to better combustion of fuel blends, requirement for energy is reduced and hence BSEC of blends decreases in comparison to baseline data. Decrease in kinematic viscosity of blends due to presence of octanol also helps in better atomization on fuel and subsequent better consumption.

4.3.3 Exhaust Temperature

Fig. 4.3 shows the variation of exhaust temperature with brake mean effective pressure. For different blends of octanol and neat diesel. The result shows that the exhaust temperature increases with the increase in brake power in all the cases. The increase in exhaust temperature with octanol addition may be due to better combustion , which leads to increased cylinder temperature and hence increased exhaust temperature.

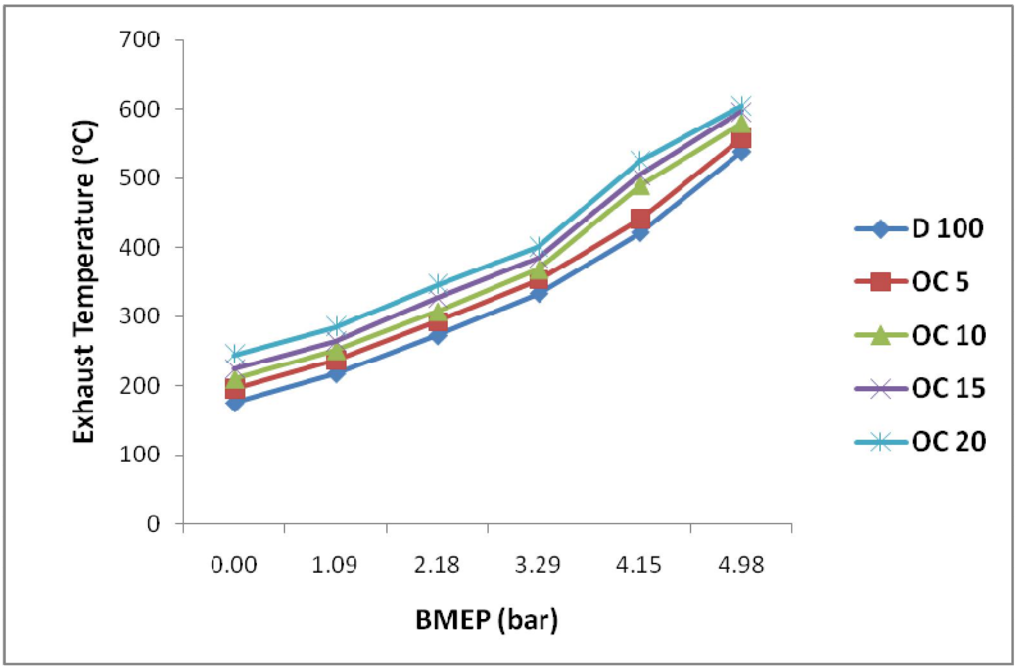

Fig.4.3: Exhaust temperature v/s BMEP

4.4 EMISSION CHARACTERISTICS

The emission characteristic of test engine on octanol diesel blends is summarized below. Main exhaust emissions considered were NO_x, CO, CO_2, UBHC and smoke Opacity.

4.4.1 NO_x Emissions

The variation of NOx emissions for all the test fuels is shown in.Fig.4.3. The NO_x emissions increased for various octanol-diesel blends till 60% engine load and thereafter a downward trend was observed. The increase in NOx emission may be attributed to proper combustion due to oxygenated fuel, which results in increased temperature of the cylinder and hence higher NOx. However, quenching effect due to higher latent heat of vaporization of octanol also plays an important role after 60% load and as a result of which NOx emissions were found to decrease after 60% load. However, NOx emissions are greater than baseline data of the diesel. This is in confirmation with Mccormick.et.al.

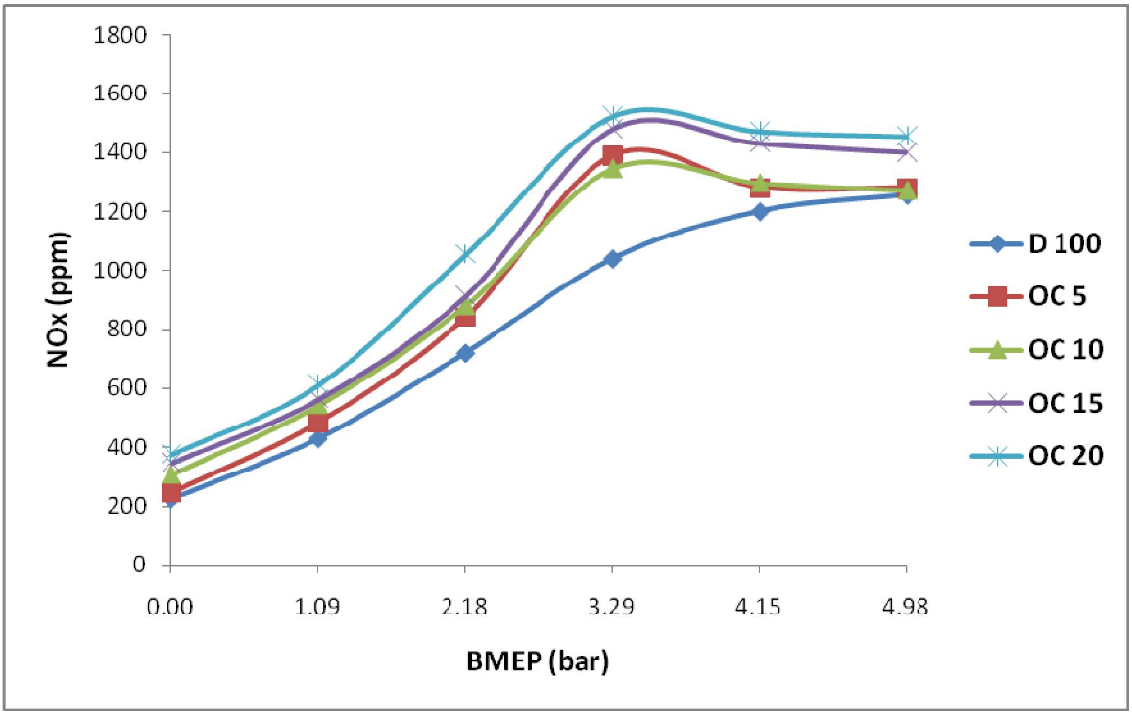

Fig. 4.4: NOx v/s BMEP

The highest NOx produced for OC 5, OC 10, OC 15 and OC 20 were 1390ppm, 1345ppm, 1480ppm and 1523ppm respectively.

4.4.2 CO Emissions

Fig. 4.4 shows that with increase in the volume of octanol in neat diesel reduces the formation of CO. Within the entire experimental range, the CO emission from the octanol diesel blend is lower than neat diesel fuel. This is due to the fact that the alcohols are oxygenated, rich in oxygen, which leads to proper combustion and hence lesser CO. Also, the atomization of fuel droplets becomes good enough to reduce the concentration of CO in the exhaust emissions. The highest value of CO for diesel fuel is 0.6%. The results are in confirmation with the results obtained by Agarwal et al [52].

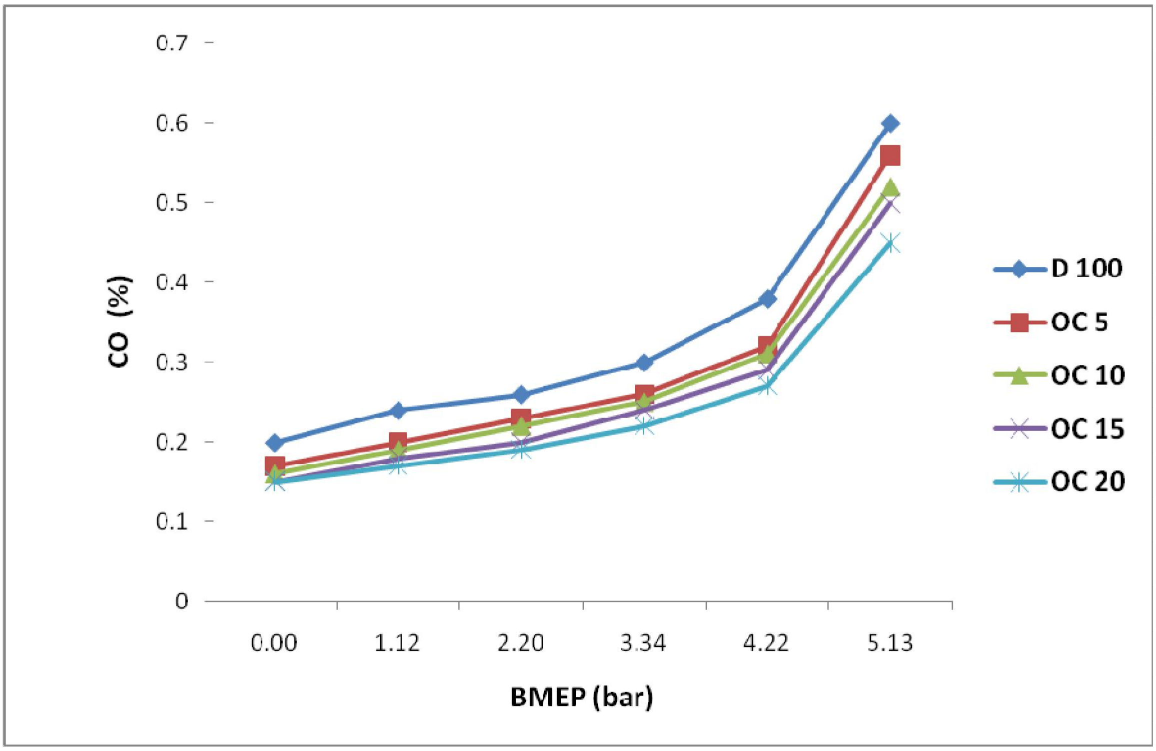

Fig. 4.5: CO v/s BMEP

4.3 CO_2 Emissions

The CO_2 emission of octanol-diesel blend fuel is higher than that of the baseline data of the neat diesel. This is because of the fact that octanol-diesel blend contains oxygen, which leads to the improved combustion and hence leads to more CO_2. Also, because of the lower kinematic viscosity, atomization of fuel droplets becomes good enough to increase the concentration of CO_2 in the exhaust emissions. The same has been depicted in the Fig. 4.5. that there is an increase in CO_2 emissions with the increase in the volume of octanol in the octanol-diesel blend. These results are in agreement with Agarwal et al.[46] and Labeckas.et.al[48]

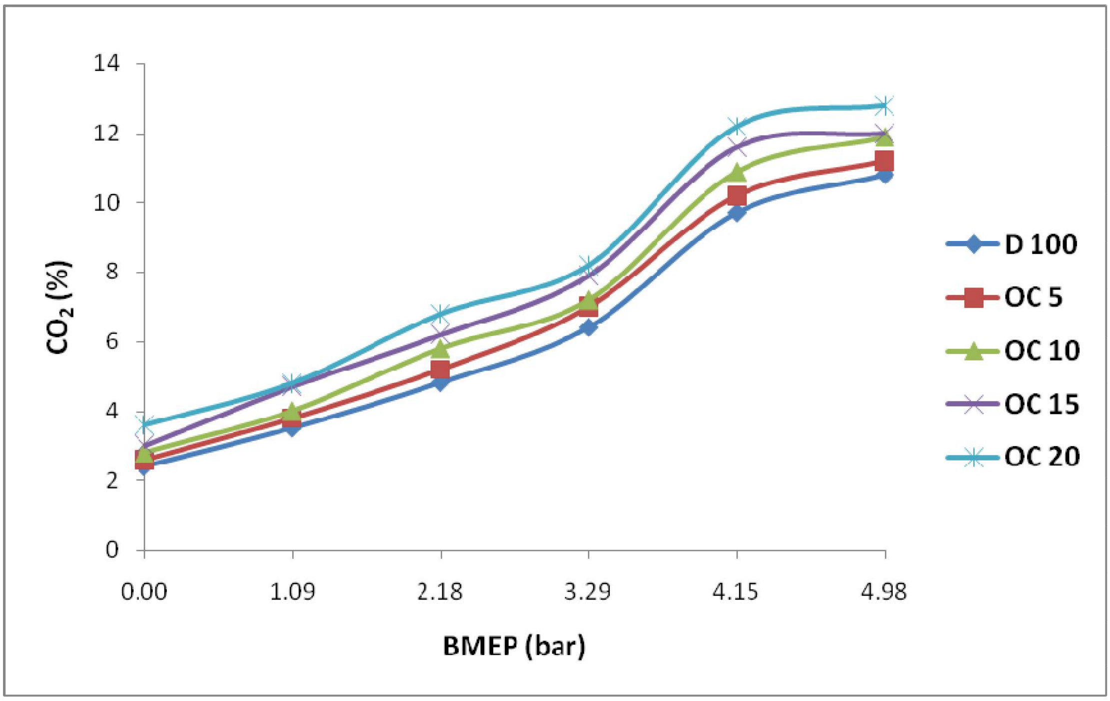

Fig.4.6: CO_2 v/s BMEP

4.4.4 Unburnt Hydro Carbon Emissions

The variation of unburnt hydrocarbon (UBHC) emissions for octanol-diesel blend and neat diesel are shown in Fig. 4.6. It was found out that UBHC for octanol-diesel blends get reduced in comparison to the baseline data of the diesel. It was found that UBHC were reduced on increasing the volume of octanol in the octanol-diesel blend. It is due to the fact that the presence of octanol which is rich in oxygen leads to the improved combustion, forming CO_2 and hence very small amount of unburnt carbon is left which combines with the hydrogen, forming small amount of UBHC These results are in agreement with Agarwal et al.[46] and Labeckas.et.al[48] in which increased CO_2 has been reported in case of oxygenated fuels

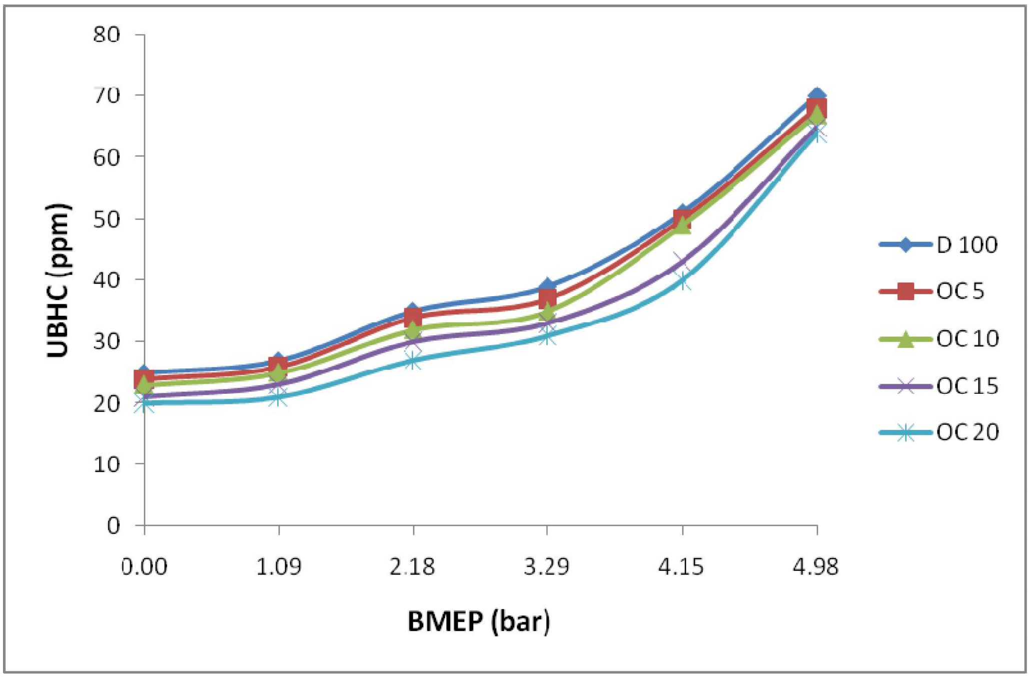

Fig.4.7: UBHC v/s BMEP

4.4.5 Smoke Opacity

Fig. 4.7 shows the comparison of smoke opacity for all the test fuels at different load conditions.

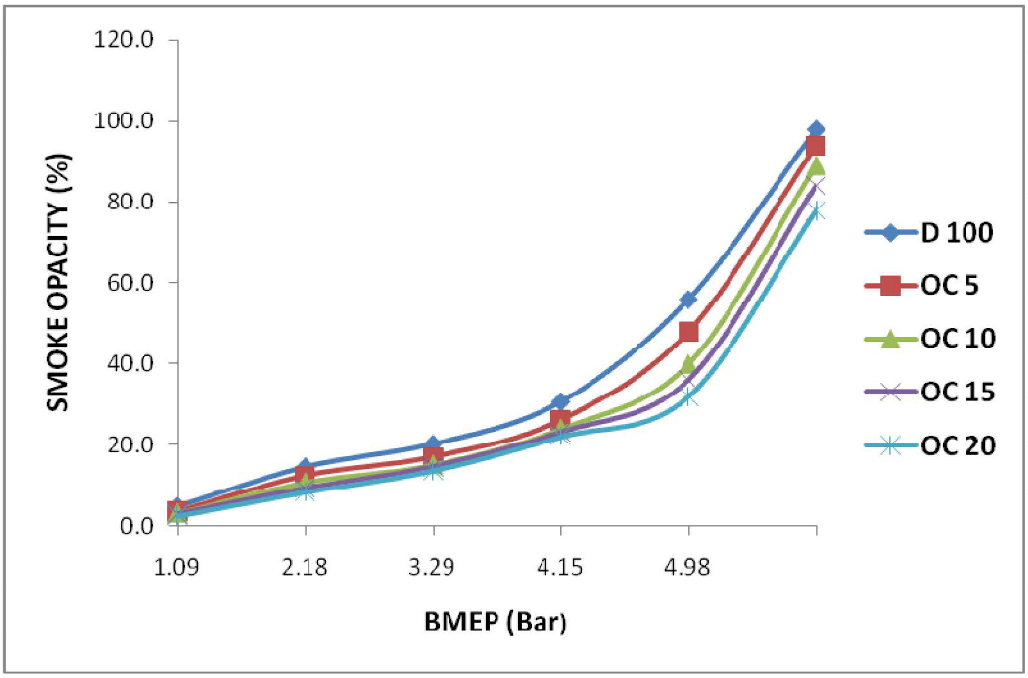

Fig.4.8 Smoke Opacity Vs BMEP

Within the experimental range, the smoke opacity for neat diesel fuel is on the higher side than that of the octanol-diesel blend. Blending of octanol in diesel has resulted in reduction in smoke at all load. This has been because of additional oxygen in octanol which have resulted in better combustion of octanol-diesel blend have also resulted in better atomization resulting in improved combustion hence lower smoke opacity. These results are in agreement with the results of Dogan [43] and Rakopoulos [44].

CHAPTER 5

CONCLUSIONS AND SCOPE FOR FUTURE WORK

The purpose of the present study was to evaluate the performance and emission characteristics of octanol diesel blend on an unmodified diesel engines. On the strength of exhaustive engine trial, the following major conclusions have been drawn:

1. The brake thermal efficiency of the octanol diesel blends (OC 5, OC 10, 0C 15 and OC 20) were found higher than neat diesel (D100).
2. The brake specific energy consumption was found to be lower for the blends in comparison to neat diesel.
3. Carbon monoxide and hydrocarbon emission were lower for octanol diesel blends in comparison to diesel fuel as alcohols are oxygenated fuels which lead to the proper combustion thereby reducing the formation of CO and UBHC. However, smoke opacity was more for octanol diesel blends as compared to diesel fuel.
4. The nitrogen oxide emission was found to increase for octanol diesel blends due to the fact that when proper combustion takes place, the cylinder temperature increases which in turn increases the exhaust temp, hence leading to more NOx. However, it was also observed that there was a reduction in NOx beyond 60% load, which was mainly due to quenching effect.

Future Work:

On the basis of present work done, the following directions are indicated for further investigations and developments.

In the present study, octanol concentration was limited up to 20%. It is suggested that higher concentration of octanol may be explored in the near future work.

In the present study, an unmodified diesel engine was used, however, it is expected that certain modifications may be required for better performance. Therefore, the engine design may be modified, specially the injection system for using blends of 1-octanol and diesel.

The short term trial of engine was carried out in the present work. There is an urgent need to carry out long term endurance test to assess the suitability of 1-octanol-diesel blends on an engine.

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